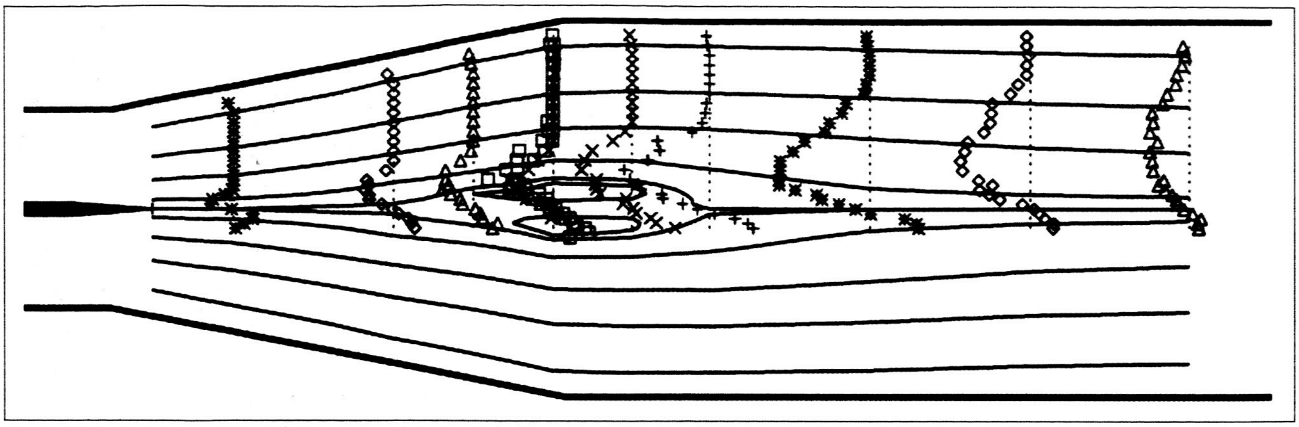

Fig. 1. Test section geometry with streamlines and uv Reynolds stress profiles overlaid.

V-22 Osprey Shipboard Interactional Aerodynamics Investigation

Kurt Long, Greg Zilliac

The U.S. Navy is currently conducting an extensive land-based and shipboard flight test program to evaluate the V-22 Osprey tilt-rotor aircraft. During shipboard tests aboard USS SAIPAN (LHA 2), V-22 test pilots experienced a roll anomaly while descending from hover. This anomaly consisted of uncommanded roll oscillation of approximately a 90-degree amplitude. Postflight analysis revealed that the roll was consistent with factors that might include an aberration in the aircraft's flight control systems logic, or air-load asymmetries caused by vehicle/ship interactional aerodynamics. Based on related ongoing shipboard air-wake measurement efforts at the Fluid Mechanics Lab (FML), the Navy requested FML support in investigating possible aerodynamic causes for the incident.

In an attempt to identify the cause of this anomaly, a 1/120-scale model of the V-22 Osprey's side-by-side, three-bladed, counterrotating twin rotor system was designed, constructed, and installed in the FML 32- by 48-inch wind tunnel (figure 1). Significant full-scale incident conditions were duplicated in the wind tunnel, including relative wind speed and direction, and deck spotting

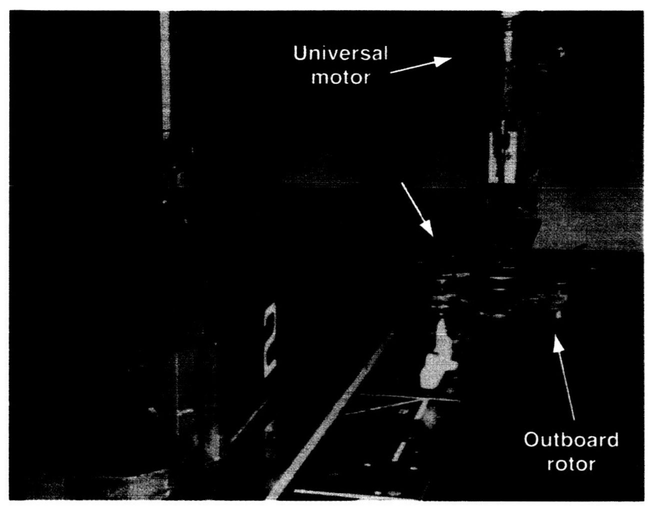

Fig. 1. 1/120-scale LHA and V-22 models..

location, and the presence of the upwind parked H-46 helicopter. To facilitate smoke (laser sheet and ambient illumination) and tuft-flow visualization, the tunnel was operated at approximately 40 feet per second. To ensure the correct ratio of rotor downwash to incoming ambient wind velocities, the rotors were spun at approximately 20,000 revolutions per minute, producing average downwash velocities of 60 feet per second. A 1.5-horsepower universal motor, speed-governed by a feedback controller, powered the rotors via a system of gears and belts. The rotors and motor were mounted to an instrumented roll pivot, which was able to record roll moment variations, by means of a strain gage, as the model was moved to various locations over the deck. This assembly was mounted on an automated traversing and data collection system, enabling precise positioning and measurements around the ship deck.

The tests investigated flow patterns in the vicinity of each rotor disk. Flow-field pattern variations with height demonstrated clearly that a large ground vortex (figure 2) forms upwind of the inboard rotor at very low wheel heights above deck. The presence of this ground vortex is consistent with prior full-scale tests and with video from the actual incident. When the rotor system was moved laterally, the vortex tended to vary in size and location, depending on model proximity to the deck edge. The effects of ship superstructure on flow asymmetries showed that the port-side superstructure tends to trap the upwind ground vortex, whereas superstructure removal produced smaller upwind vortices and flow asymmetries.

The tests also investigated the effect of deck proximity on the vehicle roll moment. When the rotor system was moved laterally from a position outboard of the deck edge inwards to a position over the desired landing spot (figure 3), the roll moment was found to vary significantly, further substantiating the flow-visualization findings. The roll moment was found to also vary with traverse height, providing further insight into the complicated shipboard rotorcraft interactional environment.

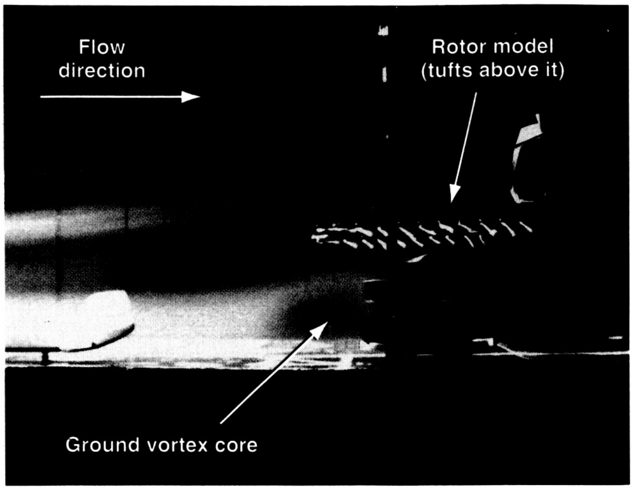

Fig. 2. Side view of upwind ground vortex.

Point of Contact: G. Zilliac
(650) 604-0613
gzilliac@mail.arc.nasa.gov

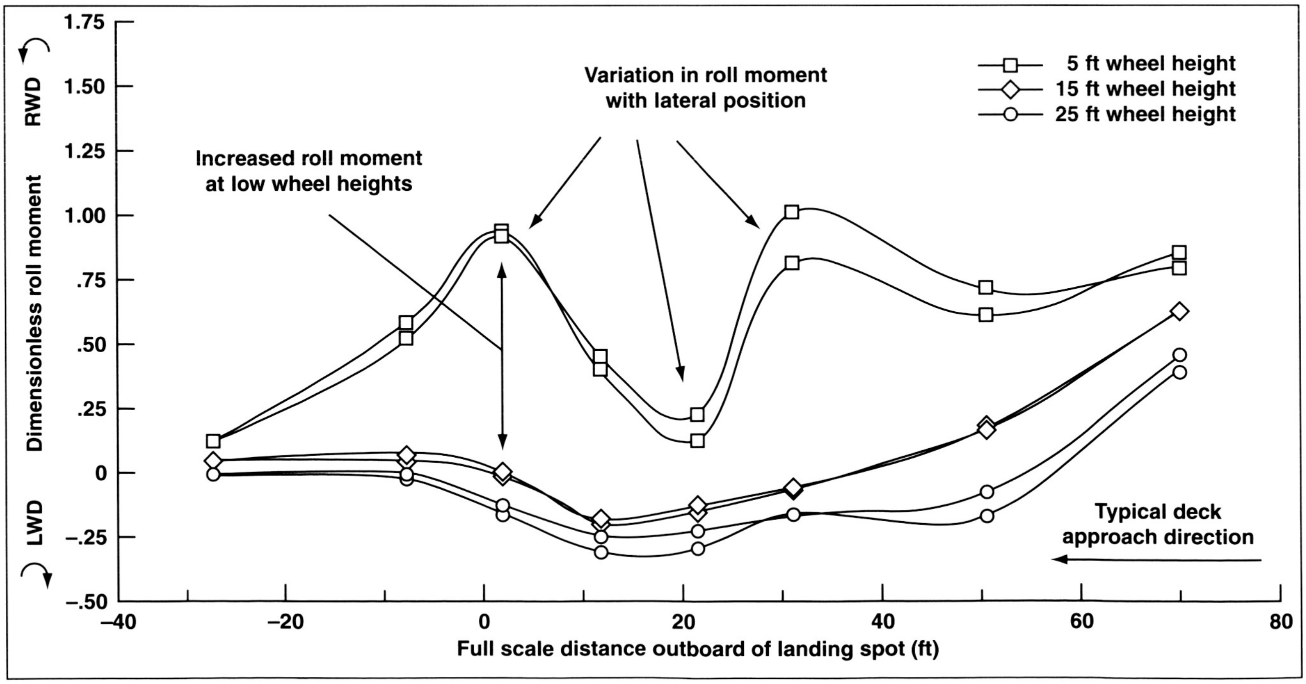

Fig. 3. Steady-state roll moment variation with height.